SULFURYL FLUORIDE (Vikane®)

RISK CHARACTERIZATION DOCUMENT

Volume III

Environmental Fate

Environmental Monitoring Branch
Department of Pesticide Regulation
California Environmental Protection Agency

ENVIRONMENTAL FATE OF SULFURYL FLUORIDE

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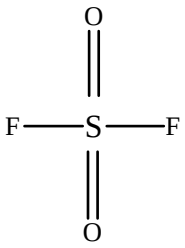
- **Chemical Description**



Common Name:	sulfuryl fluoride
Chemical Names:	sulfuryl fluoride; sulfuric oxyfluoride
Trade Name:	Vikane®
CAS Registry Number:	2699-79-8
Molecular Formula:	F_2O_2S
Molecular Weight:	102.1

Sulfuryl fluoride is a colorless, odorless gas belonging to the chemical family of inorganic acid halides. It is non-corrosive to metals, stable to light, and thermally stable up to 400 °C when dry. When heated to decomposition in air, very toxic hydrogen fluoride and sulfur dioxide fumes are emitted. Sulfuryl fluoride is soluble in water without hydrolysis (750 ppm at 25 °C, pH 7), but reacts in aqueous alkaline media via nucleophilic attack on the S atom and displacement of an F ion. It is also soluble in common organic solvents such as ethanol, toluene, and carbon tetrachloride (British Crop Protection Council, 1994; Cotton and Wilkerson, 1988; Lewis, 1991; O'Neil, 2001; Royal Society of Chemistry, 1994; U.S. Environmental Protection Agency Office of Toxics, 1985). Additional physical and chemical properties are summarized in Table 1.

Fish and wildlife data on the ecological effects to non-target organisms are not available. Because sulfuryl fluoride is a gas, it is not feasible to develop such data in accordance with U.S. Environmental Protection Agency guidelines. Therefore, basic wildlife toxicology tests and ecological effects risk assessments were not required (U.S. Environmental Protection Agency, 1985).

Table 1. Physical and chemical properties of sulfuryl fluoride (Dow Agro Sciences, 2001; Kenaga, 1957).

Physical/Chemical Property	Value
Melting Point	-136 °C
Boiling Point	-55 °C
Vapor Pressure	1.16×10^{4} mm Hg (20 °C)
Water Solubility	750 ppm (25 °C, pH 7)
Soil Adsorption Coefficient (K_{oc})	6.1 cm^3/g
Henry's Law Constant (K_h)	3.28×10^{-2} atm-m^3/mol
Octanol-water Partition Coefficient (K_{ow})	2.57

- **Regulation**

Sulfuryl fluoride has been classified as a federally restricted use pesticide for the acute inhalation hazard and possible acute toxicity hazard in human criteria (U.S. Environmental Protection Agency, 2002). Consequently, it was designated a restricted material pursuant to section 14005.5 of the Food and Agricultural Code. Other criteria for a restricted material designation in this section include posing a danger to public health, or a hazard to crops, domestic animals, farm workers, or the environment. Restricted materials are possessed and used by persons only under permit of the county agricultural commissioner.

The Birth Defect Prevention Act (Stats. 1984, Ch. 669, § 1) mandates the listing of sulfuryl fluoride in section 6198.5 of Title 3, California Code of Regulations. The 200 priority pesticide active ingredients listed in this section are suspected of being hazardous to people, and have widespread use and significant data gaps. All data requirements for sulfuryl fluoride have been submitted to the Department of Pesticide Regulation (DPR).

- **Use Profile**

Sulfuryl fluoride is a non-systemic insecticide/rodenticide used for the fumigation of sealed structures and their contents (construction materials, furnishings, and household effects) such as dwellings (including mobile homes), buildings, barns, vehicles, fumigation chambers, rail cars, and surface ships in port. There were no registered uses involving direct application of sulfuryl fluoride to agricultural crops, edible commodities, or feed. The U.S. Environmental Protection Agency, however, granted permanent tolerances for its use in post-harvest fumigation of walnuts and raisins in 2004 (U.S. Environmental Protection Agency, 2004). Sulfuryl fluoride is registered to control existing infestations of insects and related pests such as drywood termites, powder post beetles, old house borers, death watch beetles, bedbugs, cockroaches, clothes moths, rats, and mice (Dow Agro Sciences, 2000; Thomson, 2000). Vikane®, the only end-use product as of September 10, 2004, is marketed as a liquefied gas in pressurized steel cylinders (99.8 %

sulfuryl fluoride).

Full pesticide use reporting in California was implemented by DPR in 1990. All agricultural use must be reported monthly to the county agricultural commissioners. The county agricultural commissioners forward these data to DPR, who annually compiles and makes available a pesticide use report. Agricultural use is defined as including applications to parks, golf courses, cemeteries, rangeland, pastures, and rights-of-way. Although use in structural pest control is excluded from the definition, the use of pesticides designated as restricted materials pursuant to section 14005.5 of the Food and Agricultural Code must be reported. For non-agricultural applications, detailed information such as base meridian/township/range/section is not provided.

Figure 1 is a graphical representation of total pounds of sulfuryl fluoride used in California from 1993 through 2002. Total use ranged from 1,502,091 pounds in 1993 to 3,042,882 pounds in 2002. The average annual use for this reporting period was 2,172,705 pounds. Sulfuryl fluoride is used in all California counties. Table 2 and Figure 2 show use by county from 1999 through 2002 for counties with annual use over 60,000 pounds. Use of sulfuryl fluoride occurs throughout the year. Table 3 and Figure 3 show monthly use for 1999 through 2002 (DPR PUR Database).

Figure 1. Sulfuryl fluoride reported use from 1993 through 2002 (DPR PUR Database).

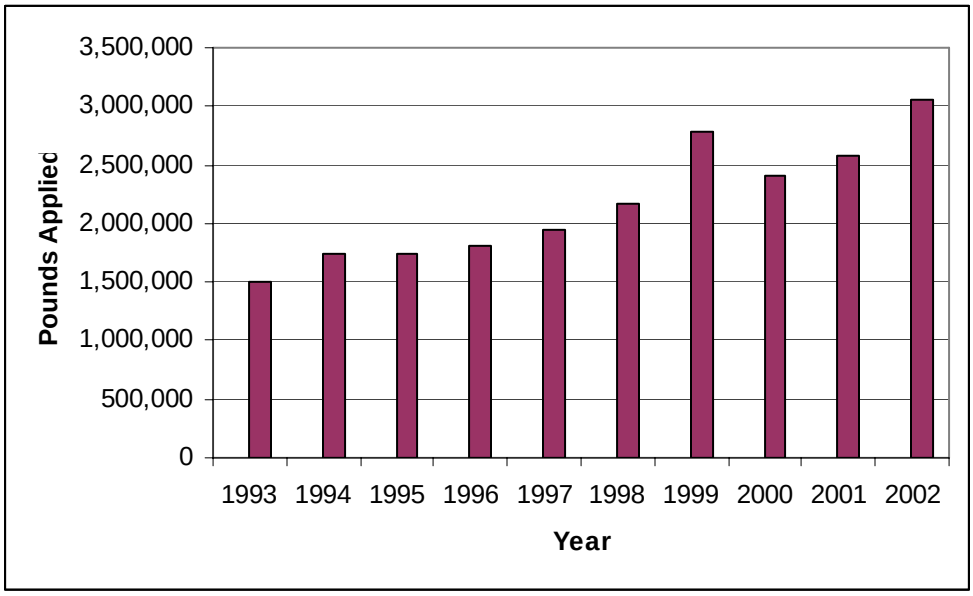


Table 2. Sulfuryl fluoride use by county from 1999 through 2002 for counties with annual use over 60,000 pounds (DPR PUR Database).

	Pounds Applied			
County	1999	2000	2001	2002
LOS ANGELES	924,560	806,192	970,514	1,180,047
ORANGE	466,694	401,705	424,410	460,257
RIVERSIDE	60,888	65,823	68,205	84,920
SAN BERNARDINO	65,623	72,120	94,850	94,336
SAN DIEGO	385,621	371,728	368,295	441,987
SANTA BARBARA	75,864	101,523	68,460	67,879
SANTA CLARA	348,223	163,556	149,792	172,909
VENTURA	110,019	121,268	91,279	100,452

Figure 2. Sulfuryl fluoride use by county from 1999 through 2002 for counties with annual use over 60,000 pounds (DPR PUR Database).

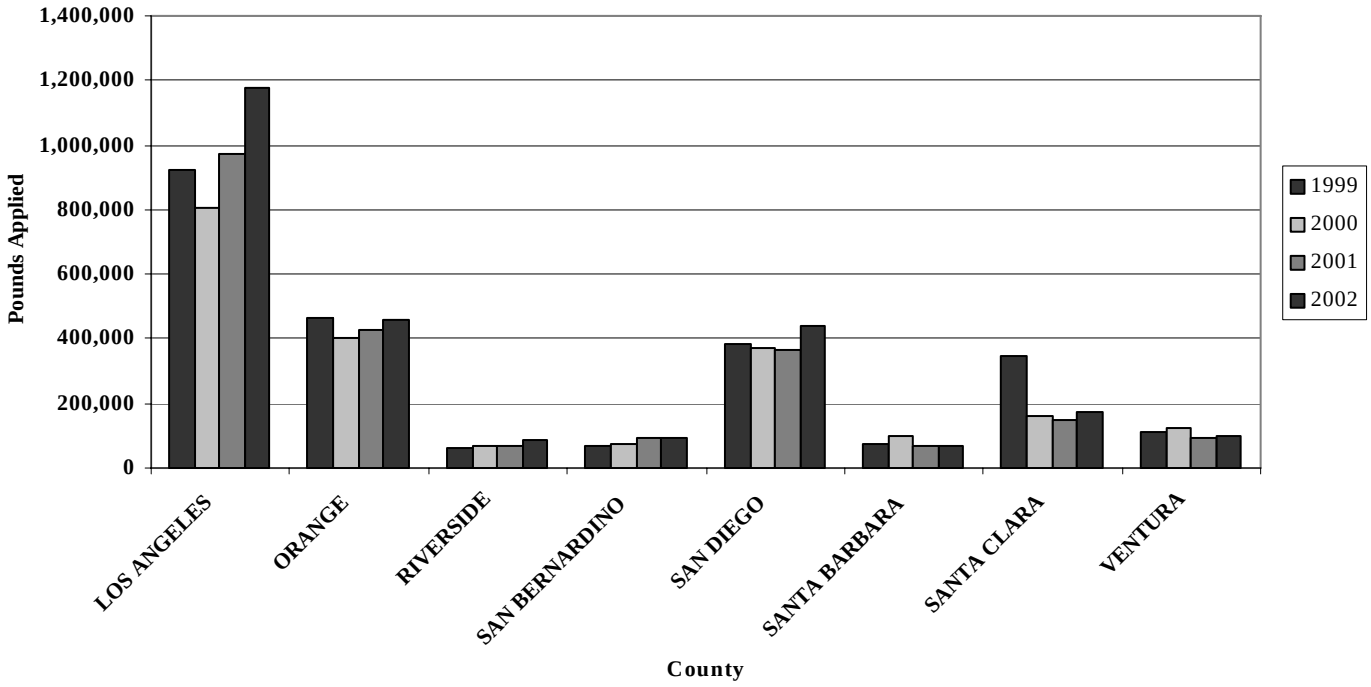
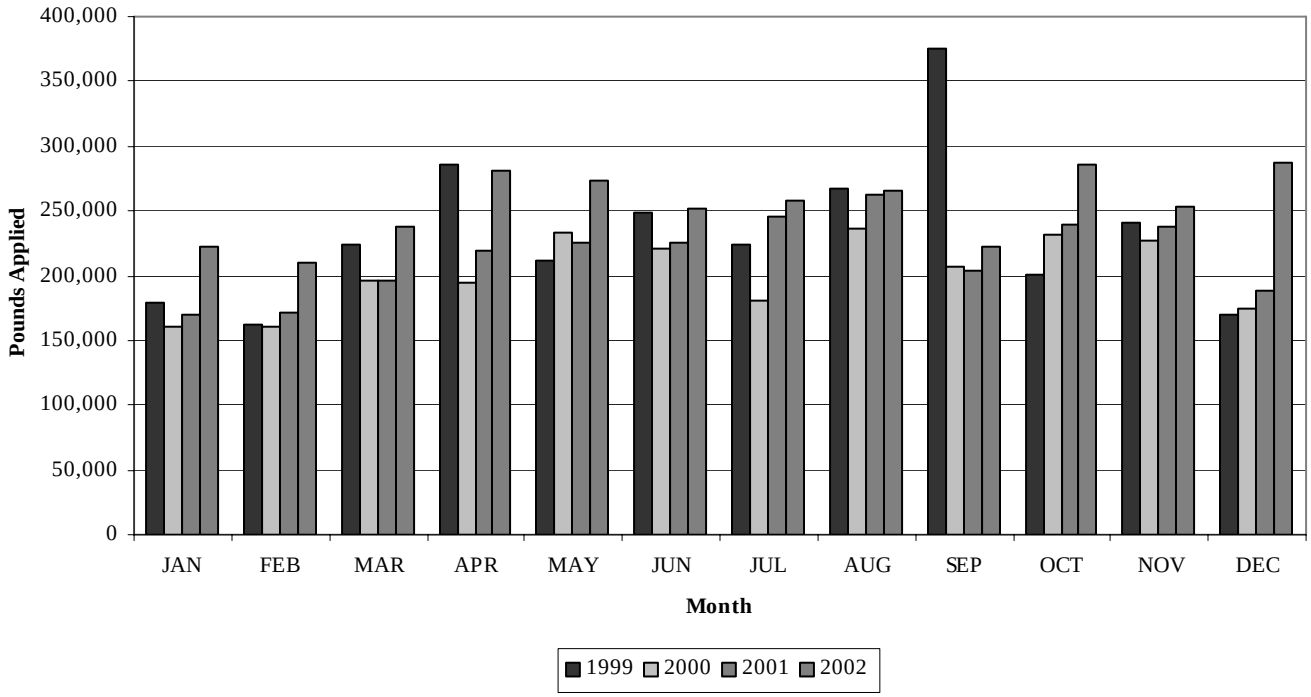


Table 3. Sulfuryl fluoride use by month from 1999 through 2002 (DPR PUR Database).

	Pounds Applied			
Month	**1999**	**2000**	**2001**	**2002**
JAN	179,834	160,416	170,225	222,873
FEB	162,015	160,289	171,134	209,864
MAR	224,130	195,438	196,833	237,214
APR	285,000	194,342	220,012	281,138
MAY	211,533	232,685	224,886	273,011
JUN	249,326	220,102	225,631	251,060
JUL	223,716	181,141	245,243	258,170
AUG	267,484	236,445	262,752	265,702
SEP	374,980	207,176	203,207	222,319
OCT	201,058	231,002	239,846	285,104
NOV	241,076	226,863	238,150	253,724
DEC	170,162	174,711	187,921	287,703

Figure 3.Sulfuryl fluoride use by month from 1999 through 2002 (DPR PUR Database).



- **Environmental Fate**

Fate in Soil and Biota

Data addressing the fate of sulfuryl fluoride in soil and biota is not available. That data was not required for re-registration due to sulfuryl fluoride's chemical properties and its registration for strictly indoor uses (U.S. Environmental Protection Agency, 1985). Following application and aeration of treated structures, sulfuryl fluoride is dissipated into the atmosphere in the gaseous state. There would be little likelihood that residues would leach to ground water.

Fate in the Atmosphere

Sulfuryl fluoride enters the atmosphere in the gas phase. Once present, it may be transformed and then removed through reactions with atmospheric radicals (OH and NO_3) and ozone (O_3). The potential for human exposure to sulfuryl fluoride in the vapor phase and subsequent transformation products is therefore related to the rate of dispersion and potentially to the atmospheric lifetime and reaction rates for removal from the atmosphere. A search of the open science literature produced no citations relevant to the fate of sulfuryl fluoride in the atmosphere or if it absorbs light at wavelengths greater than 290 nm. The Estimation Programs Interface (EPI) Suite™ is a Windows® based series of physical/chemical property and environmental fate estimation models developed by the EPA's Office of pollution Prevention Toxics and Syracuse Research Corporation. AOPWIN™ , an individual model in EPI Suite™, estimates the gas-phase reaction rate for the reaction between a chemical and OH, the most prevalent atmospheric oxidant (Meylan and Howard, 1993). The model also determines if NO_3 reaction will be important, and gas-phase O_3 reaction rates are estimated for olefins and acetylenes. Atmospheric half-lives are automatically calculated using assumed average OH and O_3 concentrations. AOPWIN™ used on sulfuryl fluoride resulted in a prediction of no reaction with the OH radical. In addition, there were no structure matches in the model's experimental database. Although it is possible that sulfuryl fluoride does not photolyze in the troposphere or react with OH radicals, NO_3 radicals, and O_3, no experimental data are available to confirm this. The uptake of sulfuryl fluoride into cloud water with subsequent hydrolysis is unlikely since it is soluble in water without hydrolysis. Based on the vapor pressure and aqueous solubility data, rain-out (wet deposition) of sulfuryl fluoride is estimated to be of no importance.

The desorption of gaseous sulfuryl fluoride from 13 representative structural and household commodities have been evaluated (Scheffrahn et al., 1987). Concrete blocks, gypsum/cardboard drywall, wood, fiberglass insulation, polystyrene insulation, topsoil, carpet padding, polyester cushion fiber, wool fabric, cotton fabric, leather baseball gloves, latex baby bottle nipples, and plastic toy soldiers were fumigated in a 4.3 m^3 chamber at 36 mg/L (approximate maximum label rate for drywood termites) and 360 mg/L for 20 hours. During aeration, airborne levels desorbing were determined at 2, 8, and 26 hours, and 5, 20, and 40 days by gas chromatography of the headspace in sealed commodity vials. It was found that 9 of the 13 commodities fumigated at the maximum rate desorbed less than 5 ppm sulfuryl fluoride at 2 hours. At 26 hours after the start of aeration, all commodities except polystyrene insulation desorbed less than 5 ppm. Several commodities were still off-gassing after 5 days. Desorption half-lives for selected commodities up to 5 days post-aeration ranged from 9.3 hours for latex baby bottle nipples to 36 hours for polyester cushion fibers.

Little or no data on sulfuryl fluoride's environmental and atmospheric loss processes are available. There are no experimental data to confirm that it photolyzes in the troposphere or reacts with OH radicals, NO_3 radicals, or O_3. It is entirely possible that sulfuryl fluoride has a long or very long atmospheric lifetime and should therefore be considered a greenhouse gas.

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